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16. Abstract

The National Transportation Safety Board (NTSB) analyzes circumstances and data from general aviation accidents and ascribes one or more causes and/or related factors to help explain each accident. The present study was undertaken to (a) provide information regarding the circumstances surrounding fatal general aviation accidents involving spatial disorientation, and (b) define demographic and behavioral characteristics of the spatially-disoriented pilot. Computer retrievals of NTSB brief reports of all spatial disorientation accidents from 1976-92 were analyzed in terms of age and experience of pilots, actions of pilots, night or day, weather, and other conditions. The computer search yielded 1,022 reports of spatial disorientation accidents, which for the 17-year period, resulted in 2,355 fatalities. Related causes and circumstances associated with the accidents were analyzed and categorized. The frequency of spatial disorientation accidents during 1976-92 peaked at 97 fatal accidents in 1977 and generally declined thereafter. The proportion of involved pilots who held an instrument rating about doubled when comparing 1976-83 to 1984-92, over 70% of the accidents were associated with instrument meterological conditions, and about half of the accidents occurred at night. The proportion of fatal general aviation accidents associated with spatial disorientation has declined significantly since an earlier study (1970-75).

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Fatal General Aviation Accidents Involving Spatial Disorientation: 1976-1992

INTRODUCTION

In aviation, spatial disorientation refers to a false perception of distance, attitude, or motion of the pilot and the aircraft, relative to the plane of the earth's surface (2). Over the years, there have been various refinements of that definition based on a continued interest in the phenomenon (9, 12); that interest is rooted in the prevalence of spatial disorientation as a cause/factor in fatal aircraft accidents. Historically, spatial disorientation has been identified consistently as a cause in about 15% of fatal U.S. military aviation accidents. Similarly, during the period from 1970-75, civil aviation statistics showed spatial disorientation as a cause/factor in 15-16% of general aviation fatal accidents (10). The present study examined the role of spatial disorientation in fatal general aviation accidents between 1976-1992 and explored possible demographic and behavioral characteristics of spatially-disoriented pilots.

The data and approach presented here differ from that of Mortimer (12) who recently provided analyses of the relationships of a variety of factors to combined fatal and nonfatal spatial disorientation accidents in general aviation grouped across the 9-year block of 1983-1991. His analyses provide a different and useful perspective on this historically significant aspect of aviation mishaps. His assessments include types of aircraft, crash severity, environment, pilot certifications, and other pilot characteristics such as profession, physical/psychological impairments, sex, and aspects of flying experience.

METHODS

Requests were made to the National Transportation Safety Board (NTSB) for computer print-outs of report briefs of all spatial disorientation accidents from 1976 through 1992. Although there have been changes in format and content over time, these briefs each contain certain standard information regarding aviation accidents (statement of cause, nature of injuries, etc.). The reports were examined and analyzed in terms of type of accident, age and experience of pilots, actions of pilots, night or day, weather, and other conditions.

RESULTS

Tabulations over the 17-year period (1976-1992) yielded a total of 51,444 accidents (11) of which 9,269 included fatalities (Table 1). Overall, the combined totals of all fatal and nonfatal general aviation accidents increased from 1976-1978 and then declined regularly through 1992. The number of fatal accidents also reached a peak in 1978 and declined thereafter in a slightly irregular but consistent pattern (Table 1). While "all accidents" declined by about 50% in number from 1978-1992, the number of fatal accidents declined by about 40%. That difference is reflected in a pattern in which the percentage of fatal accidents to total accidents shows an internally irregular but step-like increase from a range of 16.5-17.2% during 1976-80, to 17.9-18.7% during 1981-87, to 19.3-21.6% during 1988-92.

The peak year for number of fatalities in all accidents was also 1978 (1,556 deaths). The number of fatalities has declined in a consistent but slightly irregular pattern since that time to a total of 858 in 1992 – a 45% decline (Table 1). (The decline exceeded 50% in 1990 when there were 766 fatalities.)

The number of fatal accidents in which spatial disorientation was a cause/factor peaked in 1977 (Figure 1) and has shown a steady if irregular decline of about 70% through 1992 (Table 2). Thus, on a proportional basis, the reduction from peak incidence of fatal general aviation accidents involving spatial

Data in this report were presented at the annual meeting of the Aerospace Medical Association in May 1995. The assistance of Carol Floyd, NTSB, in providing data printouts is gratefully acknowledged.

TABLE 1

Fatalities Related to Spatial Disorientation (SD) in General Aviation Accidents
(Data columns 1, 2, 3, and 5 are from reference 11)

Year	Flight Hours (x 1,000)	Total Accidents	Total Fatal Accidents	% Fatal Accidents to Total Accidents	Number of Fatalities in All Accidents	Number of Fatalities in SD accidents	% SD Fatalities of Total Fatalities
1976	30,476	4023	662	16.5	1226	204	16.6
1977	31,577	4083	663	16.2	1280	223	17.4
1978	34,887	4216	719	17.1	1556	216	13.9
1979	38,641	3818	631	16.5	1221	191	15.6
1980	36,401	3590	618	17.2	1239	196	15.8
1981	36,803	3500	654	18.7	1282	220	17.2
1982	29,610	3233	591	18.3	1187	159	13.4
1983	28,673	3077	556	18.1	1069	126	11.8
1984	29,059	3016	545	18.1	1042	114	10.9
1985	28,322	2738	498	18.2	955	87	9.1
1986	27,073	2582	474	18.4	967	112	11.6
1987	26,972	2494	447	17.9	838	104	12.4
1988	27,446	2386	460	19.3	800	100	12.5
1989	27,920	2230	431	19.3	768	93	12.1
1990	28,510	2214	442	20.0	766	60	7.8
1991	27,226	2170	431	19.9	781	67	8.6
1992	23,792	2074	447	21.6	858	83	9.7
Totals	513,388	51,444	9,269		17,835	2,355	
% of Total Accidents				18.0			13.2

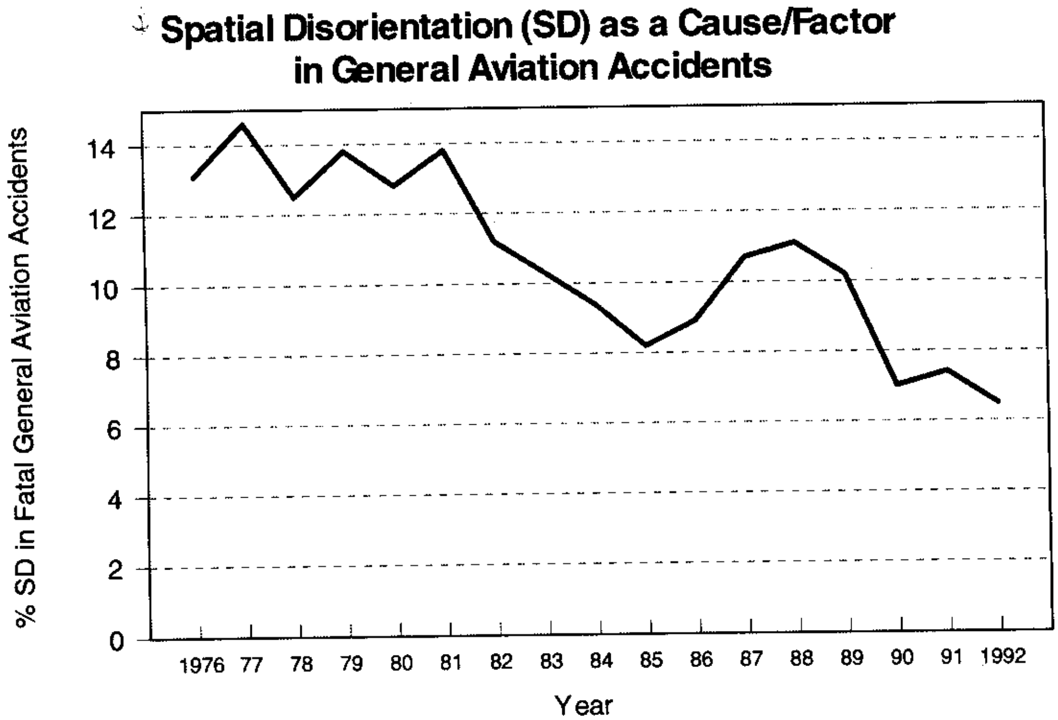

Figure 1. Number of Fatal Accidents with Spatial Disorientation as the Cause/Factor: 1976 - 1992.

TABLE 2

Spatial Disorientation (SD) as a Cause/Factor
in Fatal General Aviation Accidents (Data column 1 is from reference 11)

Year	Total Fatal Accidents	SD Cause	SD Factor	Total SD Cause/Factor	% SD Cause/Factor
1976	662	87	0	87	13.1
1977	663	97	0	97	14.6
1978	719	89	1	90	12.5
1979	631	87	0	87	13.8
1980	618	78	1	79	12.8
1981	654	90	0	90	13.8
1982	591	64	2	66	11.2
1983	556	53	4	57	10.3
1984	545	40	11	51	9.4
1985	498	34	7	41	8.2
1986	474	36	6	42	8.9
1987	447	36	12	48	10.7
1988	460	41	10	51	11.1
1989	431	38	6	44	10.2
1990	442	22	9	31	7.0
1991	431	27	5	32	7.4
1992	447	28	1	29	6.5
Totals	9269	947	75	1022	
% of Total Fatal Accidents		10.2	0.8	11.0	

disorientation (about 70%) markedly outpaced the reduction in the incidence of fatal accidents in general (about 40%) during this 1976-1992 time period. Similarly, with regard to fatalities in spatial disorientation accidents (Table 1), the peak (223) occurred in 1977; that number declined irregularly to 83 (a 63% reduction) in 1992 (and was as low as 60 – a 73% decline from peak – in 1990).

As a proportion of all fatal accidents (Table 2), the proportion attributable to spatial disorientation has declined from a high of 14.6% in 1977 to a low of 6.5% in 1992 (a reduction of 55%). A similar finding emerges from the data regarding the proportion of deaths in spatial disorientation accidents to total fatalities; that percentage declined from 17.4% in 1977 to 9.7% in 1992 – a 44% reduction – but was as low as 7.8% in 1990 – a 55% reduction (Table 1).

Spatial Disorientation and the Pilot

Table 3 provides the age distribution of pilots involved in fatal spatial disorientation accidents. The greatest incidence (29.9%) is in the fifth decade of life (ages 40-49); that coincides with the peak age group for all active pilots (3,4). The vast majority of these pilots (71.5%) held private pilot certificates, 12.1% had commercial pilot certificates, and 7.2% were student pilots.

TABLE 3

Age of Pilots in Fatal Accidents with Spatial Disorientation as a Cause/Factor *

	Age in Years							
Year	< 20	20-29	30-39	40-49	50-59	60-69	70-79	80-89
1976	2	13	25	26	19	2	0	0
1977	3	20	19	29	19	5	1	0
1978	0	13	25	22	26	4	0	0
1979	2	19	16	22	22	6	0	0
1980	2	25	17	22	11	2	0	0
1981	2	12	22	31	19	3	0	0
1982	1	12	16	20	11	4	1	0
1983	0	8	16	20	10	1	0	0
1984	0	13	9	16	10	2	1	0
1985	0	4	15	9	8	5	0	0
1986	0	5	17	12	3	4	0	1
1987	0	6	7	17	9	8	1	0
1988	0	5	11	17	9	8	1	0
1989	1	1	8	14	12	6	2	0
1990	0	5	6	8	7	2	3	0
1991	0	5	9	8	7	3	0	0
1992	0	3	5	11	6	3	1	0
Totals	13	169	243	304	208	68	11	1
%	1.3	16.6	23.9	29.9	20.5	6.7	1.1	0.0

* N=1017 - the ages of 5 pilots were not recorded

TABLE 4

Experience of Pilots in Fatal Accidents with Spatial Disorientation as a Cause/Factor

	Total Flight Hours									
Year	< 100	100-199	200-299	300-399	400-499	500-999	1000-4999	5000-9999	10000 + >	Unknown
1976	13	16	11	6	3	16	12	2	1	7
1977	14	20	11	9	2	14	15	1	3	8
1978	8	20	8	10	4	14	18	2	0	6
1979	9	15	11	9	5	11	16	3	3	5
1980	12	12	6	9	4	16	12	4	2	2
1981	11	15	8	9	4	12	18	3	0	10
1982	9	16	5	5	3	4	14	1	1	8
1983	4	9	4	6	4	12	10	2	0	6
1984	3	11	5	2	5	4	10	2	1	8
1985	3	5	1	7	3	10	7	2	2	1
1986	6	4	5	4	3	4	12	1	2	1
1987	3	4	4	4	1	9	18	3	2	0
1988	3	10	5	0	1	13	15	0	3	1
1989	3	3	6	3	4	5	13	3	3	1
1990	3	3	2	4	1	7	9	2	0	0
1991	2	3	4	1	2	9	8	2	1	0
1992	3	1	4	4	2	2	10	1	2	0
Totals	109	167	100	92	51	162	217	34	26	64
%	10.7	16.3	9.8	9.0	5.0	15.9	21.2	3.3	2.5	6.3

With regard to flying experience, 48.2% of the pilots had 500 or more total flight hours (Table 4). Among those pilots with less than 500 hours, the greatest incidence (16.3%) was in the category of 100-199 hours of flying experience. For the number of hours each pilot had logged in the type of aircraft being flown during the accident, two categories (50 hours or fewer and 51-200 hours in type) each comprised about 25% of the total pilots; that translates to approximately 35% in each of the two categories based on the known hours logged (Table 5) since about 30% of the cases were recorded as unknown.

Historically a significant proportion of spatial disorientation accidents occurs in adverse weather. "Instrument Meteorological Conditions" (IMC) as opposed to visual meteorological conditions (VMC) most often describe the weather in such accidents. Table 6 indicates that the proportion of pilots with instrument-ratings has increased by about 50% over the 1976-1992 time span, while the proportion of private pilots to total pilots has remained about the same and number of accidents has declined (6,7,8).

The extent to which "altered states" of the pilots, as evidenced by the presence of alcohol and other drugs, were associated with fatal spatial disorientation accidents was assessed (Table 7). Overall, 7.0% of the accidents involved some drugs (and 1 case of hypoxia). Alcohol was the most prevalent drug involved at 5.6% over the 17-year span. However, the rate of alcohol involvement averaged less than 2% from 1987-1992 and averaged greater than 7% for the preceding 11 years. These rates of alcohol involvement in spatial disorientation accidents are somewhat lower than the rates obtained for all fatal accidents in general (1), where, for example, the rates ranged from 5.5 to 8.2% during 1987-1992.

TABLE 5

Experience of Pilots in Fatal Accidents with Spatial Disorientation as a Cause/Factor

	Hours in Type of Aircraft					
Year	< or = 50	51-200	201-500	501-999	= or > 1,000	Unknown
1976	32	22	8	3	2	20
1977	21	32	12	3	2	27
1978	23	26	16	1	4	20
1979	21	20	14	3	5	24
1980	20	17	10	4	1	27
1981	24	19	5	2	3	37
1982	12	22	8	0	2	22
1983	17	16	5	0	1	18
1984	11	12	5	0	7	16
1985	11	10	6	1	2	11
1986	5	11	9	2	1	14
1987	12	8	8	5	2	13
1988	9	15	6	3	0	18
1989	10	11	7	2	5	9
1990	9	5	5	2	3	7
1991	5	8	6	1	4	8
1992	5	6	3	1	3	11
Totals	247	260	133	33	47	302
%	24.2	25.4	13.0	3.2	4.6	29.5

Weather and Spatial Disorientation

Inclement weather and spatial disorientation interact in a significant fashion to produce fatal accidents. To examine this interaction more clearly, various features of fatal accidents in which spatial disorientation and weather were cause/factors are summarized in Table 8. Flight was <u>initiated</u> into adverse weather in 21.3% of these accidents; flight was <u>continued</u> into adverse weather in 41.3%. At the time of accidents, VMC weather conditions existed only 17.9% and IMC conditions 80.2% of the time (1.9% not reported).

By far the greatest proportion of accidents, 85%, occurred as a result of collision with the ground, water, or a structure, but inflight breakup occurred in 14% (Table 9). No weather briefing was recorded in 37.3% of the fatal flights; briefings were recorded in 51.7% of the cases and partial briefings (usually "cut short by pilot") in 1.2% (10% were missing data or "unknown").

The most prevalent weather condition involved fog (47.8%) with rain the next most frequent (Table 10). Low ceilings were involved in a major proportion (54%) of these accidents. Also, 40.9% of the accidents occurred during daylight hours, 50.6% at night, 5.3% at dusk, and 1.8% at dawn (1.5% unknown or not given).

DISCUSSION

The number of fatal general aviation accidents in which spatial disorientation was attributed to be a cause or factor has declined considerably since 1977. That decline parallels declines in total accidents

TABLE 6

Prevalence of Private Pilots and Instrument Rated Pilots in the Airman Population
(Data columns 1, 2, and 4 are from references 6, 7, and 8)

Year	Total Pilots	Private Pilots	% Private Pilots	Instrument Rated Pilots	% Pilots Instrument Rated
1976	744,246	309,005	41.5	211,364	28.4
1977	783,932	327,424	41.8	226,334	28.9
1978	798,833	337,644	42.3	236,312	29.6
1979	814,567	343,275	42.1	247,096	30.3
1980	827,071	357,479	43.2	260,461	31.5
1981	764,182	328,562	43.0	252,535	33.0
1982	733,266	322,091	43.9	256,073	34.9
1983	718,004	318,643	44.4	254,271	35.4
1984	722,376	320,086	44.3	256,584	35.5
1985	709,540	311,086	43.8	258,559	36.4
1986	709,118	305,736	43.1	262,388	37.0
1987	699,653	300,949	43.0	266,122	38.0
1988	694,016	299,786	43.2	273,804	39.5
1989	700,010	293,179	41.9	282,804	40.4
1990	702,659	299,111	42.6	297,073	42.3
1991	692,095	293,306	42.4	303,193	43.8
1992	682,959	288,078	42.2	306,169	44.8
Totals	12,496,527	5,355,440		4,451,142	
% of Total Pilots		42.9		35.6	

TABLE 7
Incidence of Alcohol/Drugs/Hypoxia
in Fatal Spatial Disorientation (SD) Accidents

		Altered States					
Year	Total SD Accidents	Alcohol	Marijuana/ Cocaine	Prescription	Mixed Alcohol/Drug	Hypoxia	% of SD Accidents
1976	87	7	0	1	0	0	9.2
1977	97	5	0	0	0	0	5.2
1978	90	6	0	0	0	0	6.7
1979	87	4	0	0	0	0	4.6
1980	79	4	0	0	0	0	5.1
1981	90	8	0	1	0	0	10.0
1982	66	2	0	0	0	0	3.0
1983	57	7	0	0	0	0	12.3
1984	51	2	0	0	0	0	3.9
1985	41	5	0	1	1	0	17.1
1986	42	5	1	0	0	0	14.3
1987	48	0	0	0	1	0	2.1
1988	51	1	0	1	1	0	5.9
1989	44	0	1	1	0	0	4.5
1990	31	1	0	1	0	0	6.5
1991	32	0	1	1	0	1	9.4
1992	29	0	0	1	0	0	3.4
Totals	1022	57	3	8	3	1	
% of SD accidents		5.6	0.3	0.8	0.3	0.1	7.0

and fatal accidents in general over the same time period, but the reduction has been proportionately greater for spatial disorientation.

In the 1970-1975 period, spatial disorientation accounted for 15% of general aviation accidents, only 15% of the pilots involved had instrument ratings, and about 88% of the accidents involved "initiating or continuing flight into adverse weather" (10). Those proportions changed dramatically over the 17 subsequent years. For example, during the 1984-1992 period, the proportion of fatal spatial disorientation accidents ranged from 6.5-11.1% of all fatal accidents, pilots involved in those accidents who had instrument ratings ranged from 33.3-54.2%, and the proportion involving "flight into adverse weather" ranged from 43.9-59.1%. Moreover, the latter decline from 1970-1975 levels is largely attributable to a sharp reduction in the incidence of continuing flight into adverse weather.

The decline in fatal spatial disorientation accidents clearly has a relation to the overall reductions in the following: the number of active airmen, the number of hours flown, the number of total accidents, and the number of fatal accidents. However, the proportionately larger reduction in fatal spatial disorientation accidents over the same time period requires additional analysis. One factor – a general increase in the proportion of pilots holding instrument ratings and the (perhaps) seemingly paradoxical increase in the incidence of pilots with instrument ratings being involved in fatal spatial disorientation accidents – may be relevant. Instrument proficiency provides a remedy for the well-known interaction of weather and IMC conditions with spatial disorientation. The sharp reduction in the proportion of spatial disorientation fatal accidents which included "continued flight into adverse weather" may reflect the greater ability of pilots to handle these weather conditions because of

TABLE 8
Relationship of Instrument Ratings to Adverse Weather as a Cause/Factor in
Fatal Spatial Disorientation (SD) General Aviation Accidents

		SD Pilots with Instrument Ratings		Flight into Adverse Weather			Known Condition			
Year	Total SD Cause/Factor	Number	%	Iniatiated	Continued	% of SD Accidents	VMC	IMC	Not Reported	% IMC in SD Accidents
1976	87	14	16.1	15	41	64.4	8	74	5	85.1
1977	97	16	16.5	17	50	69.1	10	79	8	81.4
1978	90	20	22.2	18	53	78.9	11	78	1	86.7
1979	87	30	34.5	11	50	70.1	7	79	1	90.8
1980	79	15	19.0	17	39	70.9	18	59	2	74.7
1981	90	17	18.9	14	46	66.7	15	73	2	81.1
1982	66	11	16.7	18	28	69.7	10	56	-	84.8
1983	57	13	22.8	19	20	68.4	10	47	-	82.5
1984	51	19	37.3	9	16	49.0	7	44	-	86.3
1985	41	17	41.5	10	8	43.9	12	29	-	70.7
1986	42	14	33.3	10	9	45.2	16	26	-	61.9
1987	48	26	54.2	12	8	41.7	17	31	-	64.6
1988	51	24	47.1	16	13	56.9	12	39	-	76.5
1989	44	19	43.2	13	13	59.1	5	39	-	88.6
1990	31	11	35.5	10	8	58.1	8	23	-	74.2
1991	32	14	43.8	5	11	50.0	10	22	-	68.8
1992	29	14	48.3	4	9	44.8	7	22	-	75.9
Totals	1022	294		218	422		183	820	19	
% of SD accidents		28.8		21.3	41.3		17.9	80.2	1.9	

TABLE 9
Phase of Flight and Type of Accident in Fatal Spatial Disorientation General Aviation Accidents

	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	%
Phase of flight:																		
Takeoff	5	4	6	12	9	5	8	8	4	11	12	7	14	10	8	4	6	13.0
In flight	74	81	79	64	55	75	56	44	41	22	20	30	26	27	19	16	17	73.0
Landing	7	12	4	10	14	9	1	5	6	7	10	11	10	6	4	8	6	12.7
Unknown	1	0	1	1	1	1	1	0	0	1	0	0	1	1	0	4	0	1.3
% Inflight	85.1	83.5	87.8	73.6	69.6	83.3	84.8	77.2	80.4	53.7	47.6	62.5	51.0	61.4	61.3	50.0	58.6	
Type of accident:																		
Collision w/ground or water	72	81	71	75	65	70	58	55	42	35	37	42	42	40	29	29	27	85.1
Infight Breakup	14	16	18	12	14	20	8	2	9	5	4	5	9	4	2	3	2	14.4
Collision w/structure	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0.1
Unknown	1	0	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0.4
% Breakup	16.1	16.5	20.0	13.8	17.7	22.2	12.1	3.5	17.6	12.2	9.5	10.4	17.6	9.1	6.5	9.4	6.9	

TABLE 10

Number of Citations of Light and Adverse Weather Conditions in Fatal Spatial Disorientation General Aviation Accidents

	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	%
Light Conditions																		
Light	36	43	51	41	31	32	16	20	23	18	12	22	20	20	14	8	11	40.9
Dark	43	46	33	39	34	44	44	31	27	22	29	25	26	21	15	23	15	50.6
Dusk	2	5	2	4	10	9	4	5	1	0	1	0	5	2	1	1	2	5.3
Dawn	1	1	2	2	2	3	1	1	0	1	0	1	0	1	1	0	1	1.8
Unknown	5	2	2	1	2	2	1	0	0	0	0	0	0	0	0	0	0	1.5
% Dark	49.4	47.4	36.7	44.8	43.0	48.9	66.7	54.4	52.9	53.7	69.0	52.1	51.0	47.7	48.4	71.9	51.7	50.6
*Weather conditions																		
Rain	37	42	27	26	17	22	26	28	19	13	13	18	18	19	11	9	11	34.8
Thund	13	14	11	14	10	23	7	7	8	3	3	3	4	6	2	1	3	12.9
Fog	42	37	43	44	40	38	28	30	22	23	19	22	33	28	16	11	13	47.8
Snow	9	12	11	10	11	8	13	9	9	7	2	4	4	4	3	4	6	12.3
Haze	1	0	2	4	2	1	10	6	0	2	7	5	3	4	3	0	2	5.1
Dust	0	1	1	0	1	1	4	1	1	0	0	0	0	0	0	0	0	1.0
Ice	3	1	7	10	5	4	0	1	1	0	3	2	3	1	1	1	0	4.2
Turbulence	5	5	3	5	5	6	9	11	5	3	3	5	8	2	0	0	3	7.6
Low Ceiling	55	63	50	57	29	50	37	33	25	18	17	22	20	30	16	14	16	54.0
% Rain	42.5	43.3	30.0	29.9	21.5	24.4	39.4	49.1	37.3	31.7	31.0	37.5	35.3	43.2	35.5	28.1	37.9	34.8
% Fog	48.3	38.1	47.8	50.6	50.6	42.2	42.4	52.6	43.1	56.1	45.2	45.8	64.7	63.6	51.6	34.4	44.8	47.8
% Low Ceiling	63.2	64.9	55.6	65.5	36.7	55.6	56.1	57.9	49.0	43.9	40.5	45.8	39.2	68.2	51.6	43.8	55.2	54.0

*Total of weather conditions exceeds the number of accidents since combinations of conditions are frequently cited.

their instrument training. Another possibility is an improvement in pilot decision-making regarding the advisability of flight into weather.

Other potential positive influences include:

(i) the FAA's Accident Prevention Program and the Pilot Proficiency Award Program (Wings) (5) which have recorded increasing participation by pilots in recent years. Of particular relevance are the "Back to Basics" seminars introduced in 1986 as part of the Accident Prevention Program; these seminars specifically address the 12 most prevalent causal factors in aviation accidents.

(ii) the educational material and vertigon training provided by the Civil Aeromedical Institute's Aeromedical Education Division at air shows and accident prevention classes around the country. The vertigon (the newest version is called Gyro-I) provides an impressive spatial disorientation experience in a safe, ground-based device and specifically promotes the need for instrument proficiency in IMC and weather conditions. The device has been "ridden" by thousands of pilots since its introduction in 1970.

CONCLUSION

The proportion of fatal general aviation accidents attributed to spatial disorientation has declined significantly. Along with that decline has been a large reduction in the proportion of spatial disorientation accidents that were associated with "continuing flight into adverse weather." The relative incidence of IMC conditions in those accidents has not changed.

Improvements in the accident rate for spatial disorientation appears distally related to general reductions in flight hours, total accidents, and fatal accidents and more proximally related to an increase in the proportion of pilots with instrument ratings, FAA training programs, and improved decision-making on the part of general aviation pilots.

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